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Markhor: Robotic Mining Platform

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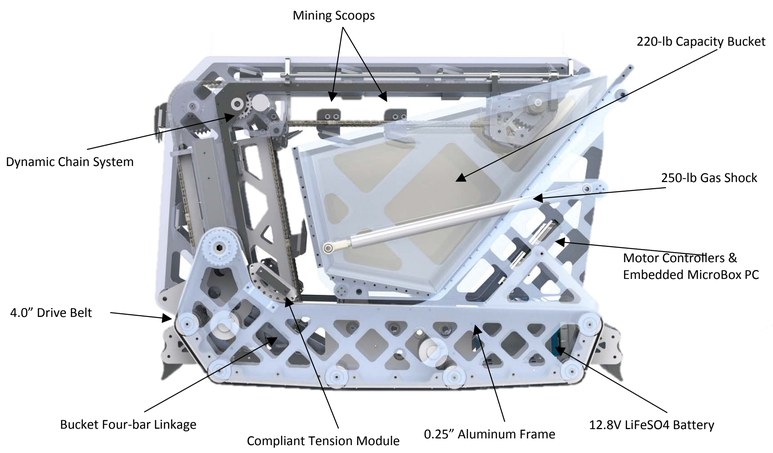
Abstract

In-situ resource utilization, or the use of the resources available in a foreign environment, is crucial to the success of manned missions to Mars; however, it is a severely underdeveloped technology. This project explores the development of a rover capable of operating in a simulated Martian environment. The rover is capable of mining large amounts of simulated ice chunks from below the surface, driving its payload to a collection station, and unloading all of the collected material. This project is partially inspired by NASA's Robotic Mining Competition which served to establish a set of guidelines around which the robot was constructed.

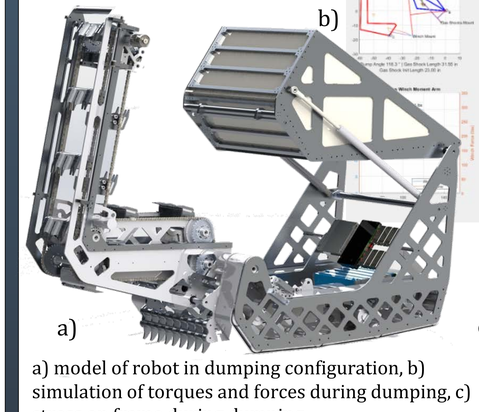
Rover Design



Specifications	
Dimensions (LxWxH)	40in x 28in x 29in
Weight	176 lbs.
Rated Payload	220 lbs.
Maximum Speed	10 in/s
Operating Time	12 min
Material Collection Rate	14 oz/s
Collection Depth	16 in

Material Collection and Release

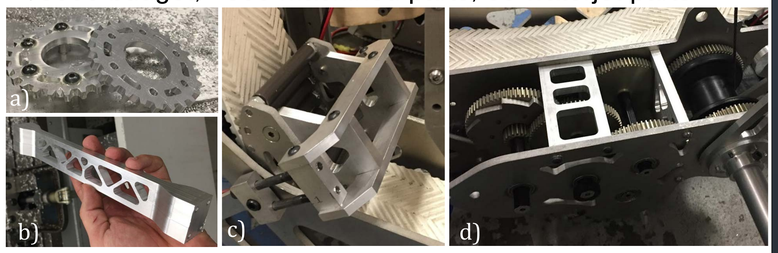
- Dynamic chain system: keeps scoop chain tensioned & actuated between two independent carriages
- Allows for excavation at depths up to 16" with consistent dump into bucket without dust creation
- Scoop guide rail system increases robustness of system
- Synchronized material deposit system: single motor gearbox design with co-axial output shaft controls winch & four-bar mechanism



a) model of robot in dumping configuration, b) simulation of torques and forces during dumping, c) stress on frame during dumping

Manufacturing and Assembly

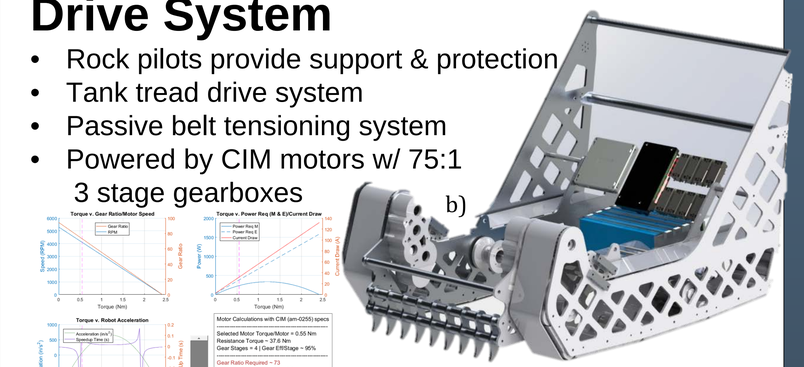
- Lightweight rigid aluminum chassis w/ sandblasted finish
- $8000 budget, ~300 machined parts, 30 waterjet parts



a) Custom dynamic chain sprockets, b) upper carriage link, c) assembled passive tension module, d) winch and four-bar linkage gearbox

Drive System

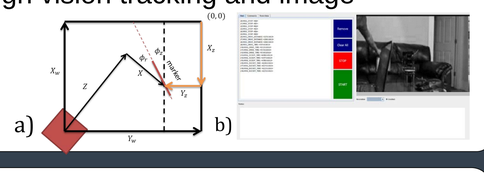
- Rock pilots provide support & protection
- Tank tread drive system
- Passive belt tensioning system
- Powered by CIM motors w/ 75:1 3 stage gearboxes



a) torques experienced by drive system
b) isolated model of drive system

Software

- Queue-based augmented autonomy
- Low bandwidth message protocol
- Localization through vision tracking and image processing



a) mathematical representation of localization algorithm, b) control station user interface

Field Testing

- Tested in mock Martian mining environment w/ sand & gravel
- Capable of mining full 220lb load in 4 minutes
- Dumps total load in 15 seconds

a) fully assembled robot